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Tensile and Physical Properties of Unsaturated Polyester/Potash Feldspar Composites: The Effect of Potash Feldspar Loading

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Abstract. In order to reduce the cost and improve the performance of potash feldspar (PF)/unsaturated polyester (UP) composites, the effects of potash feldspar loading towards mechanical, physical, and morphology of UP/PF composites were studied. In this study, the UP/PF composites with varies ratio of potash feldspar (2.50, 5.00, 7.50, and 10.00 phr) were prepared by using casting technique. The results showed that the potash feldspar can improve mechanical properties of UP/PF composites effectively. For the best tensile and flexural properties of UP/PFF composites, the appropriate amount of potash feldspar was 5.00 phr. The potash feldspar amount for preparation of UP/PFF composites should be based on the processing requirements and the demands for different working conditions.

Keywords: Inorganic filler reinforced composites, potash feldspar loading, mechanical properties

1. Introduction

The demand for feldspar as a raw material in composite industries is continuously increasing. Feldspar has been traditionally separated from quartz using amine type cationic collectors and hydrofluoric acid as activator for feldspar [1]. Feldspars are the most common constituents in crystalline rocks and make up about 60 percent of the earth's crust. They may be technically defined as aluminosilicates of sodium, potassium, calcium and barium. Most commonly, the feldspars are considered as solid solutions of three limiting compounds, $NaAlSi_3O_8$, $KAlSi_3O_8$, and $CaAl_2Si_2O_8$, which are respectively known as soda feldspar, potash feldspar and lime feldspar [2]. A feldspar is typically referred to as 'potash' if there is significantly more potassium than sodium (typically there will be 2-5% Na_2O). Potash feldspar is kind of insoluble potash ore, with a very stable property [3].

In the fabrication of ceramic material, feldspar serves to form a glassy phase at low temperatures, and as a source of alkalis and alumina in glasses. It improves the strength, toughness, and durability of the ceramic body and cements the crystalline phase of other ingredients. Therefore, feldspars are economic minerals for manufacturing of porcelain, glass, some ornamental stones, and event thermoset composites [4]. The

most widely used thermoset resin are polyester. The reaction of unsaturated polyester resin is a free radical chain growth copolymerization between the styrene monomer and unsaturated polyester molecule. Polyester act as cross linker while styrene as an agent to link the adjacent of polyester molecules. Generally, unsaturated polyester (UP) resins are produced by a typical polycondensation process using maleic anhydride, saturated dicarboxylic acid and various aliphatic diol [5].

However, until now no study has been done towards potash feldspar-unsaturated polyester as composites where this kind of composites may have potential in manufacturing industries. Hence, in this research, potash feldspar has been utilized as reinforcement filler UP/PF composites. As to achieve the main goal in this research, UP/PF composites have been casted according to different amount of filler loading. Meanwhile, the morphology and functional groups properties of these composites was characterized using field emission scanning electron microscopy (FESEM) and Fourier transforms infrared (FT-IR), respectively.

2. Experimental Part

2.1 Materials

In this research, Unsaturated Polyester (UP) was used as the matrix in the composite while Potash Feldspar (PF) were used to study the effect of different filler loading towards its mechanical, physical and morphology of composites. Methyl Ethyl Ketone Peroxide (MEKP) was used as hardener which shorten the time taken for composite to cure. PF with mean particle size of 0.18µm was obtained from Commercial Minerals (M) Sdn. Bhd., Penang, Malaysia.

2.2 Preparation of composites

For the sample preparation, the mixture of unsaturated polyester/PF composite were prepared by using casting technique. The unsaturated polyester and PF with different loading (2.5, 5.0, 7.5, and 10.0 phr) were mixed together by using mixture for about 10 minutes. The MEKP as hardener was added into the mixture at 0.6% for all composition and be mix for 3 minutes at room temperature in order to achieve homogenous solution. After 3 minutes from an addition of MEKP, the mixture was cast into a plate and allowed to cure at room temperature.

2.3 Tensile test

Tensile properties were carried out according to ASTM D638 by using Instron 5569 with crosshead speed of 4 mm/min. Rectangular shaped specimens was used for the test. For each blend composition, 5 samples were used. From the tensile test, tensile strength, modulus at 100% elongation and elongation at break were achieved.

2.4 Flexural test

Sample composites were prepared as per ASTM D256 standards in rectangular cross section specimens (75mm x 12mm x 12mm) as shown in figure 3.5. Three-point bending test was performed by using Universal Testing Machine (UTM) with a maximum load cell 5000 N. The test was carried at a crosshead speed 3 mm/min at 60 mm gauge gap.

2.5 Swelling behavior test

The swelling behavior test was carried out accordingly to ASTM D570 standard. For the swelling behavior test, three of each blend compositions with the dimension of 10mm x 20mm x 30mm were immersed into container that contained toluene for 3 days at room temperature. After 3 days, the samples were taken out and wiped with tissue paper. The samples were weighed by using an analytical balanced with 0.1mg resolution. The percentage of mass swell (% MS) was calculated from the formulae below:

$$\% MS = \frac{W_2 - W_1}{W_1} \times 100\% \quad (1)$$

Where W1 is the weight of dry sample and W2 is the weight of wet sample [6]. The difference of weigh was calculated and recorded into the table.

2.6 Oven aging test
Weight loss process was using an oven as the surrounding condition. ASTM D570 also being used for this sample measurement, sample were weighed and recorded at the beginning of the process. The temperature of the oven was set to 80 0C for 48 hours. The formula that being used to calculate the amount of weight loss for each sample are shown as below:

$$\% WL = \frac{W_2 - W_1}{W_2} \times 100\% \quad (2)$$

Where W1 is the original weight of sample and W2 is the final weight of the sample.

2.7 Morphology analysis
In this research, for morphology of the tensile fracture failure surface of composite were carried out by using optical microscope. This test was tensile fracture failure surface sample. The magnificent used was 5x. The resolution is primarily determined by the wavelength of the light source and the numerical aperture (NA) of the objective lens.

3. Results and discussion

3.1 Swelling analysis
The percentages of mass swell of different PF loading in UP/PF composites were shown in Figure 1. By referring to the graph, percentages of mass swell were decreased from zero filler loading to 5 phr of PF, while for 7.5 increased and slightly decreasing for samples with filler loading 10phr.
Samples with zero filler loading shows the highest percentages of mass swell which is 2.95 %, this can be state that UP absorb more solution than other that contain PF filler loading. Lowest value for percentages of mass swell goes to sample with 5 phr of PF loading, this might be influence by the poor absorption of the material does this sample having less increasing of thickness.

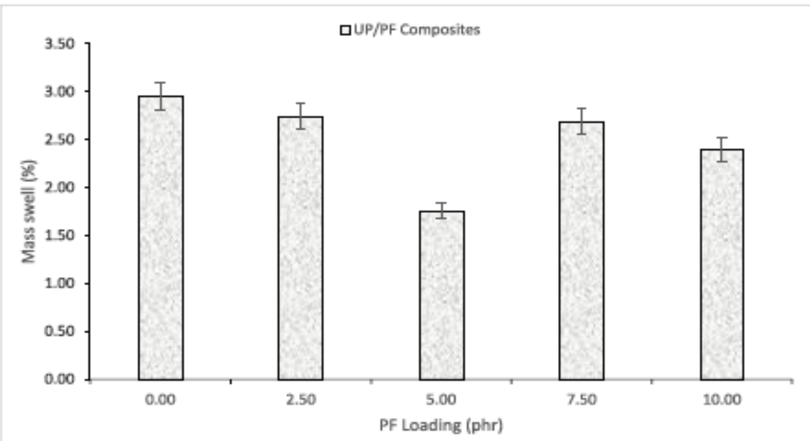

Figure 1. Effect of PF loading on percentages of mass swell in UP/PF composites

3.2 Oven aging analysis

The percentages of weight loss of different PF filler loading in UP/PF composites are shown in Figure 2. Samples were heat in oven at temperature 80 o C for 48 hours. Samples were weight before and after the oven aging and recorded. From the graph zero filler loading shows the highest percentages of weight loss which is 0.41 % compare to others. From filler loading 5 phr to 10phr, the weight loss was increased as increasing the filler loading. Oxidation and evaporation of water had occurred during the heating process which lead to loss of weight of the samples. After the aging, the samples were shrunk that created matrix material to damage [7].

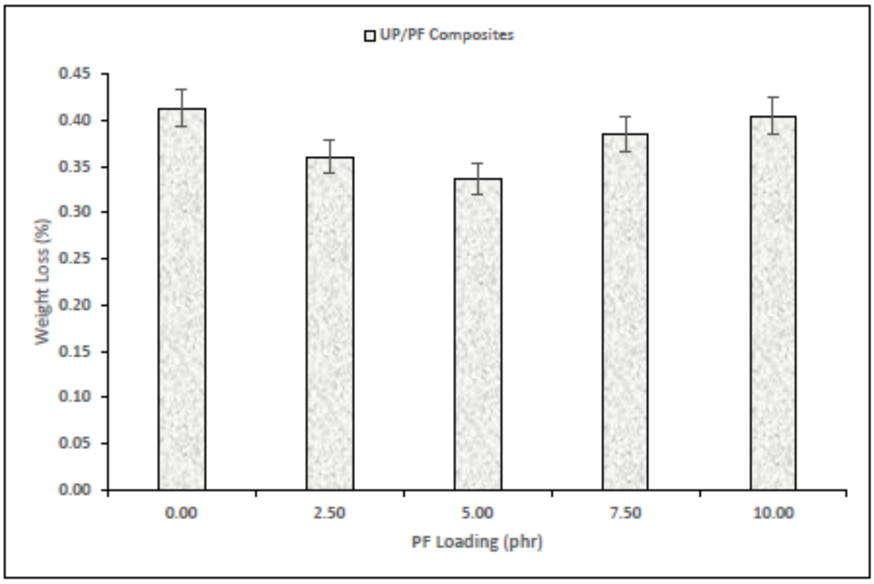

Figure 2. Effect of PH loading on percentage of weight loss in UP/PF composites

3.3 Tensile properties

Effect on tensile strength of different PF loading in UP/PF composites was shown in Figure 3. The highest tensile strength was samples with 5 phr of filler loading which is 39.08. From the graph, it can be seen that in increasing of filler loading were decreased the tensile strength of samples composites. G.O Gloria and co-researcher (2017) [8], state that the abrupt end of the linear stage characterizes elastic deformation and indicates the specimen rupture without plastic deformation. This shows that polyester resin and polyester composites are relatively brittle material.

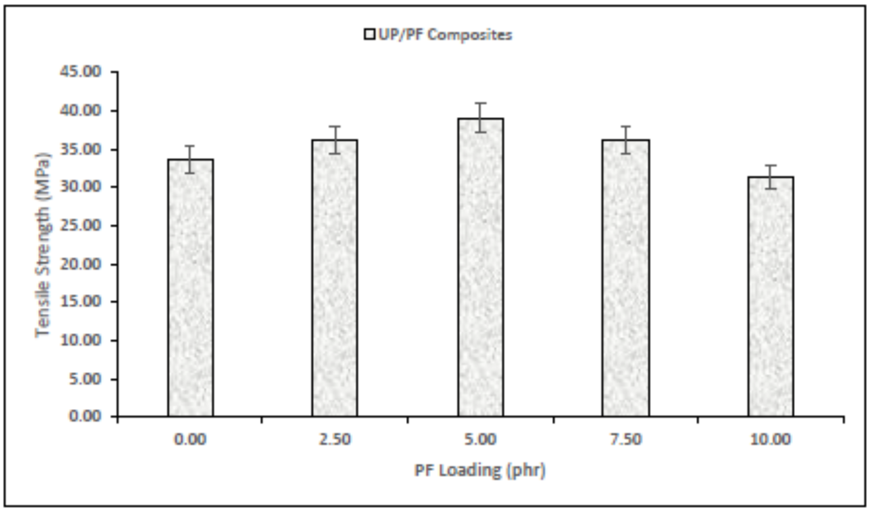

Figure 3. Effect of PH loading on tensile strength in UP/PF composites

3.4 Elongation at break

Effect of PF loading on percentages of elongation at break of tensile in UP/PF composites was shown in Figure 4. Generally, the elongation at break was a measurement of ductility of materials use [9]. Percentages of samples with zero filler and 2.5 phr filler loading shows slightly decreased towards each other which are 9.52 and 9.46% respectively. Sample with 5 phr of PF loading having the lowest percentages of elongation, this result is inversely proportional to the tensile strength graph. From 5 to 10 phr shows in increasing the percentages of elongation as increasing the filler loading. Graph also shows decreasing trend on it percentages of elongation from 0 to 5 phr PF loading. This can be state that with increasing of filler loading, will decreased the elongation at break of samples composites. The decreasing of elongation at break might be cause by the increasing of stress concentration [10].

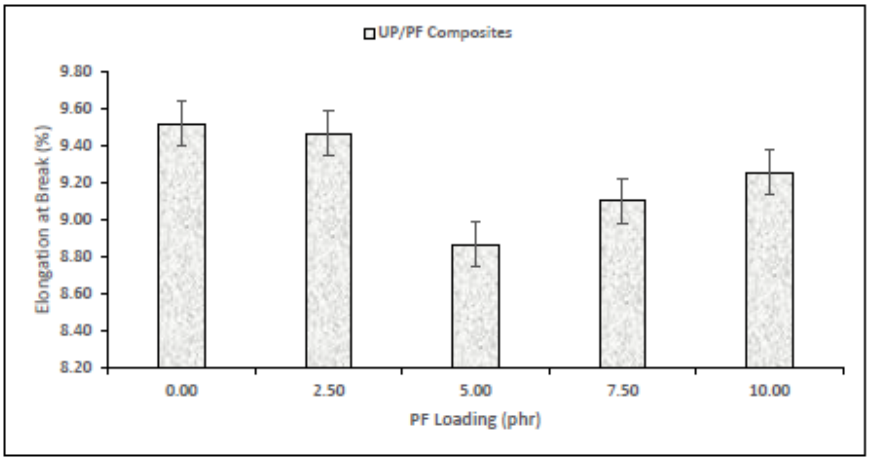

Figure 4. Effect of PF loading on percentages of elongation at break of tensile in UP/PF composites

3.5 Modulus elasticity

Figure 5 shows the effect of PF loading on modulus of elasticity of tensile in UP/PF composites. This graph usually used to express the stiffness of the material and generally increased when composites were formed [10]. From the graph, it can be seen that in increasing of filler loading, the composites were more

elastic compared to samples with filler loading 7.5 and 10.0 phr which was slightly decreased from filler 5.0 phr. Sample with 5 phr of PF loading having the highest modulus of elasticity which is directly proportional to the graph of tensile strength, this also means that sample 5 phr is stiffer than other. Tensile properties of fiber reinforced with composite material influenced by fiber/matrix interfacial bonding and fiber loading of the reinforcement [7].

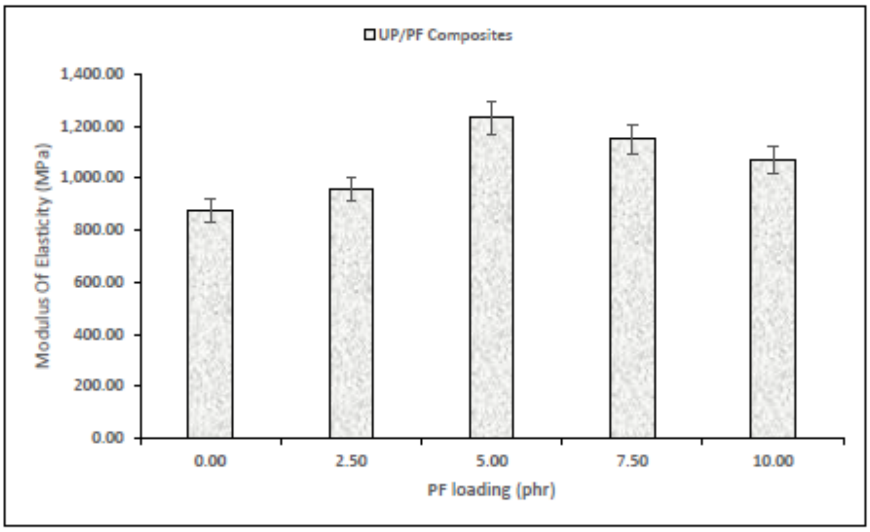

Figure 5. Effect of PF loading on modulus elasticity of tensile in UP/PF composites

3.6 Flexural properties

Figure 6 shows the effect PF loading on flexural strength in UP/PF composites. Composites samples were tested by three point-point bending technique. Flexural testing is similar to bending testing. Usually, the value of flexural strength is higher compared to value of tensile strength [11]. From the graph, it can be seen that the strength of flexural were increased with increasing of filler loading from 0 to 5 phr. Sample with 5 phr of PF loading shows the highest flexural strength which was 98.55 MPa. The value of flexural strength for samples 7.5 to 10.0 phr was slightly decrease which are 84.56 and77.06 MPa respectively. Mohamad and co researcher (2002) [12] notices that flexural behavior of the composite varies on it fiber orientation, laminate stacking and surface waviness.

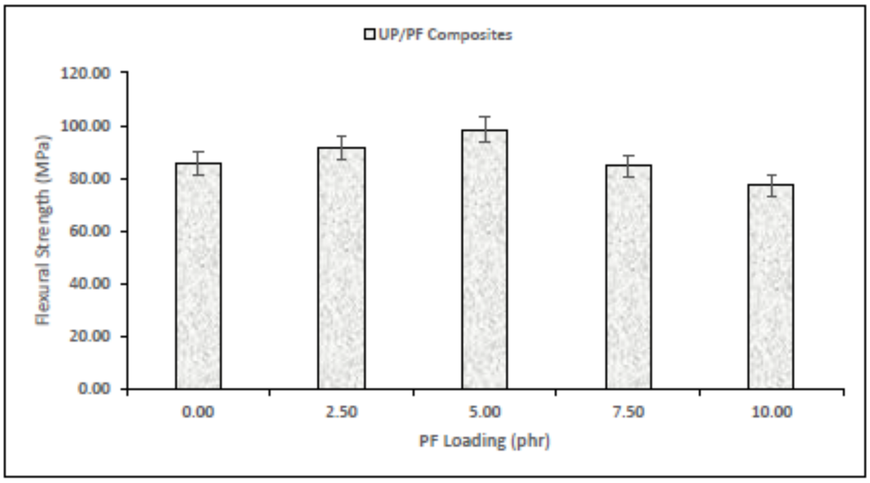

Figure 6. Effect of PF fiber loading on flexural strength in UP/PF composites

3.7 Morphology analysis

Figure 7 shows the morphology of UP/PF composites from tensile fracture failure surface for UP/PF composites without filler and 5 phr of PF loading respectively. It can be seen that at control sample having a lot of voids might be due to air bubble of matrix composites during the processing but it relatively smooth. For the 5 phr of PF in UP/PF composites, it can be seen the rough surface which contained PF filler presence uniformly distributed particles which produce the crack propagation in the composites. The appearances of the surface propagation were influenced by the solid particles of PF used in composites. The agglomeration of particles allowing for crack path and propagate [13,14].

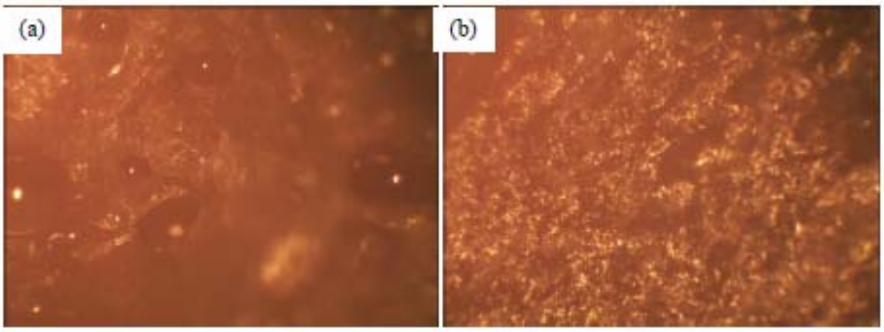

Figure 7. Morphology of UP/PF composites under Optical Microscope (OM) at 5 magnificent a) Control sample of UP/PF composites b) 5 phr of PF in UP/PF composites

4. Conclusion

1. The mechanical performance such as tensile and flexural of UP/PF composites were increased with increasing potash feldspar loading up to 5 phr.
2. The addition of potash feldspar in UP/PF composites was proved to enhance the compatibility and adhesion towards UP matrix, where all the studied mechanical properties show positive increment as the filler loading increase.
3. Inorganic filler such as potash feldspar will be an alternative and vital reinforcement filler towards manufacturing composites as it can reduce the cost of raw material with better performance in composites.

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